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# A GEOGRAPHIC STUDY OF THE MESA VERDE\*

BY

WALLACE W. ATWOOD

About thirty-five miles southwest from the base of the San Juan Mountains and near the southwestern corner of Colorado there is a maturely dissected mesa, bordered by an abrupt escarpment, which rises from one thousand to two thousand feet above the adjoining lowland. The upland area is of sufficient elevation to receive an annual rainfall which will support a covering of grass and a scattering of scrubby cedars and piñons, and thus the name Mesa Verde, a green table, was long ago suggested.

*The Origin of the Mesa Verde.*—In origin the mesa is closely related to the geomorphic changes which have affected the San Juan region of southwestern Colorado, and the details in the outline of the mesa, in the bordering escarpments, and in the canyons which subdivide the mesa, are dependent upon local geologic conditions. The Mesa Verde is but a portion of a widespread plateau, which has been dissected by streams flowing southward and southwestward from the San Juan Mountains into the San Juan River, and thence to the Colorado. The mesa and plateau surfaces appear to be portions of a late Tertiary peneplain. That peneplain probably extended northeastward over a portion of the neighboring areas where now there are mountain ranges, and far to the southwest over the Colorado Plateau district. The relationship of the surface of the mesa to the San Juan Mountains is strongly suggested by a scattering of beautifully worn gravels, which must have come from the San Juan Mountains and travelled southwestward in stream courses long before the present valleys were developed. With the uplift which closed the cycle of erosion, when this broad area was reduced to a peneplain, the San Juan Mountain area rose as a dome and the surrounding area as a slightly inclined plain. The upper surface of the Mesa Verde slopes gently to the southwest. The streams were invigorated and the uplifted and deformed peneplain was dissected. The areas of softer rocks were first reduced and the remaining upland areas

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\* From *Annals of the Assoc. of Amer. Geographers*, Vol. 1, pp. 95-100, Plates VI-VIII.

were thus defined as relief features. These relief features have been slowly yielding to the agencies of weathering and stream erosion to the present time.

*The Dissection of the Mesa.*—A hard layer of sandstone has preserved portions of the Mesa Verde, and the weathering of soft underlying shales has maintained the precipitous marginal escarpment. On the north, east, and south are the valleys of the Rio Mancos and its tributaries. On the west is the Montezuma Valley. The smaller streams tributary to the Rio Mancos on the south side of the mesa have worked headward until, in some instances, they have reached the escarpments bordering the mesa on the north and northwest. These escarpments, in turn, have been gradually retreating southward as the soft shales have been worn away, and huge blocks of the hard, overlying sandstone have fallen. In those instances where the headward growth of the valleys has reached to the margin of the mesa, the upper ends of the valleys are being gradually cut off by the retreat of the marginal escarpment. The surface of the mesa is to-day, therefore, very little like a tableland, for the canyons, which have been cut into it have left but narrow strips of upland bordered on either side by the nearly vertical faces of the canyon wall. As there is little or no water on the mesa at present, it is more common to see the stream courses dry than to find flowing water in them. The heads of the canyons are box-like, and the waters enter them as cascades or falls. The extension of the canyons northward into the mesa must be by the under-cutting at the falls and the gradual recession of the falls up stream.

*The Cliff Dwellers of the Mesa.*—The mesa top suggested to certain primitive people who formerly lived in the southwestern portion of the United States, an easily protected site for their homes. The upland could be reached only at a few points, and at those points with great difficulty. The approach of unfriendly peoples could be watched from the rim of the mesa or from outlook points on the rims of the canyons, and attempts made to scale the bordering escarpments or approach the homes through the canyons from the south could be anticipated by the dwellers on the mesa or by those in the great alcoves near the heads of the canyons. These people became the Cliff Dwellers. They built some of their homes and many watch towers on the remnants of the upland surface of the mesa, but most of their houses were built in the canyon walls. The ruins of these homes may still be found to the number of several hundred, scattered about through the area now set aside as the

Mesa Verde National Park and southward over the remaining portion of the Mesa Verde. The more remarkable of the buildings are near the heads of certain of the canyons which end just south of the southern limit of the Park. The Park authorities, however, by an act of Congress, have been given control over this region of unusual dwellings which added to the territory under their jurisdiction a bordering strip five miles in width. The alcoves which were selected for homes were worn out of the canyon walls by the agents of weathering at less resistant points in the sandstones. The dwellings are not in the underlying soft shales, but near the bedding plane between two of the great sandstone layers which form the capping of the mesa. The overhanging ledge sometimes extends as much as one hundred feet beyond the inner margin of the cave in which the home was built.

*The Character of the Houses.*—Fragments of the sandstone, after some little trimming and shaping, were used by these peoples in the construction of their homes and laid one upon the other with mortar or plaster made of the underlying clay. The homes were built from the floor of the cave to the ceiling. In some instances there are three, and in a few instances even four stories. The floors were made by placing cedar boughs from wall to wall. These cedar boughs were usually allowed to protrude beyond the walls and sometimes served as a support for platforms or balconies. The rooms are usually not more than eight or ten feet in diameter and many of them are much less than that. Many of them are without light from the outside. The dark rooms have been interpreted as granaries or storage rooms.

A few of the inner rooms in which human bones, and in some instances mummies have been found, have been interpreted as burial rooms, and it is believed that these people, after embalming their dead, stored them away in the inner recesses of their great dwellings. Among the rooms in the dwellings there are certain circular ones which have been called kivas, and these have been interpreted as ceremonial rooms. These rooms were covered over and entered from above by ladders, or through subterranean passageways. The kivas had cold air flues for ventilation, an altar, a large central fireplace, small niches in which the sacred grain was stored, and a little off the center a small circular opening about eight inches deep and four inches in diameter, which has been interpreted as a connection with the under-world which might be used when desired by those conducting the sacred services. The ceremonial rooms were some-

times rectangular; they were always well made and exceedingly strong. There were several such kivas in each dwelling and they were always in the outer portion or foreground of the little village.

*The Products and Implements of the Cliff Dwellers.*—Almost every room in the dwellings has been blackened by the soot which came from the fires used for heating or cooking. There were open fireplaces in which the people prepared their simple foods and about which they may have baked certain of the pieces of pottery. Scattered about in the rooms and in the large open space back of the rooms, where the caves have but little height, there are thousands and thousands of corncobs. Great heaps of corncobs have been found by those who have been engaged in repairing the dwellings. The corncobs were small, about the size of pop corn cobs, and it is of special interest to learn that these people raised maize in this region where now there is but one spring known, and where it would be impossible to raise grain without some elaborate method of storing the rainfall and using it through the dry season by means of irrigation ditches.

From the few relics found about the dwellings it is evident that cotton also was raised. Some game was killed, and both the cotton and the skins of animals were used for clothing. The leaves of the corn, and the leaves and cords of the yucca served in the making of sandals. The abundance of plastic clays and the necessity of vessels for carrying water led these people to be good pottery makers, and among the dwellings to-day there are many bits of ancient pottery. Occasionally a bowl or a spoon or a cup is found in the débris.

The corn was ground in large bowl-shaped stones, hollowed out for that purpose. Many of the grinding stones and bowls are still in good condition and are now preserved for the inspection of visitors. About the ruins little flint arrow-heads, used presumably for shooting small game, may be found, and at many places on the upland areas of the mesa similar arrow-heads have been picked up. Stone axes and stone knives have also been found, but no implements of metal. The Cliff Dwellers, used the grasses and leaves of the yucca, the leaves of the corn, the twigs from the willows, cedar boughs and trunks, stones, clay, cotton and the skins of wild animals. They presumably lived in peace and in an exceedingly simple way.

*The Cliff Palace.*—In the largest of the dwellings, the Cliff Palace, there are over 300 rooms. A great circular tower occupies the central position in the dwelling, and at one end is a rectangular tower, four stories high, interpreted as the home of the chief. Over

twenty kivas border this dwelling in the foreground, and behind the rooms which were closed in there is a large open space which may have been used as a playground for children or a safe retreat during an attack, or as general storage space.

Near each dwelling on the mesa there must have been a spring. There are indications that many such springs did exist. The one which is now flowing is near the head of one of the forks of the Navajo Canyon, where the Spruce Tree House is located. The dwellings at the Spruce Tree House and Cliff Palace have been somewhat repaired by representatives of the Smithsonian Institution, but this work has been so well done that the homes still appear as ruins. The débris has been cleared away and a much better idea of these ancient homes can now be obtained than before this work was done. There remain several of the dwellings which are almost inaccessible or unsafe to visit until some work of repair shall have been done.

*The Geographic Conditions at the Time of Occupation by the Cliff Dwellers.*—The origin of the mesa is seen to have been closely associated with the physiographic history of the region. Its form and the details in its architecture are due to the controlling geologic conditions. Its isolation made it attractive to a peaceful people who wished a quiet home out of the reach of unfriendly nomadic tribes. The alcoves which the Cliff Dwellers selected for their homes were due to the differential weathering of the varying formations of the mesa. The stones used in building homes were obtained from the formation immediately at hand; the clay used as mortar immediately underlay the sandstone. The scarcity of water determined the location of the homes near the springs, and compelled the people to conserve the water supply. The necessity for carrying and conserving their water supply led these people to make various kinds of water vessels and to become good pottery makers. The scarcity of level land made it necessary to cultivate small portions on the upland and on the canyon bottoms. The aridity of the climate made the food supply a difficult question for these people. The corn which they raised was small and stunted. The wild game was presumably small and scarce. Cotton was raised in but relatively small quantities.

*The Present Conditions.*—Since the Cliff Dwellers inhabited the Mesa Verde, the climate has evidently become even more arid, and the mesa could not to-day support the population which it must once have supported. The single spring would limit the inhabitants to one or at most two of the hundreds of dwellings scattered about

on the mesa and in the canyons. The almost complete absence of wild game on the mesa would add to the difficulties.

*The Age of the Ruins.*—The lack of definite legends, among the Indian tribes of the Southwest of their relationship to these ancient Cliff Dwellers seems to indicate that these homes were deserted many hundreds of years ago, and the absence of any metals about the homes suggests the same conclusion. The relationship of this entire record to the geologic history suggests that the Cliff Dwellers inhabited this region at a time much less removed than the present from the last period of glaciation in the mountains, and the question may perhaps be raised, may we not find some evidence in the homes of these ancient peoples that will indicate that they inhabited portions of our Southwest country during the last glacial epoch in North America?

## STUDIES ON CLIMATE AND CROPS\*

### 3. THE "SOLAR CONSTANT" AND THE VARIATIONS OF ATMOSPHERIC TEMPERATURE AT AREQUIPA AND SOME OTHER STATIONS

BY

HENRYK ARCTOWSKI

At my request, Prof. E. C. Pickering kindly let me utilize for my researches on Climate and Crops the not yet published observations made at Arequipa during the years 1900-1910. As these observations interest meteorologists greatly (South American data being very scarce and not easily obtainable), I shall begin this paper by a summary of the results of my calculations.

The Arequipa station has been described previously in the *Annals* of Harvard Observatory.† The installation of the thermometers has undergone no change during the eleven years taken into consideration. The instruments were observed at 8 A. M., 2 and 8 P. M. The daily maxima and minima were also recorded. Some gaps occurring here and there were not important enough to affect the averages, except in the case of the 2 o'clock observation during the month of March 1908. The adopted value  $64^{\circ}.1$  is therefore more or less hypothetical. The daily minima are also lacking from April 8th, 1909, till March 7th, 1910.

The lowest temperature,  $36^{\circ}$  F., was recorded in Aug. 1908 and the highest,  $78^{\circ}$  F., in June 1910.

The annual maxima are  $74^{\circ}$  or  $75^{\circ}$ , except in 1909 and 1910, when they were  $76^{\circ}$  and  $78^{\circ}$ . The lowest maximum recorded is  $68^{\circ}$  (Jan. 1904). This small

\* Paper 1 in this series appeared in *The Bulletin*, Vol. 42, 1910, pp. 270-282; Paper 2 in the same volume, pp. 481-495.

† *Annals of the Astronomical Observatory of Harvard College*, Vol. 39. Cambridge, Mass., 1899.